Fermi National Accelerator Laboratory
Technical Division
Development and Test Department
Mail stop 316
P.O. Box 500
Batavia, Illinois • 60510

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Measurement of the Inter-strand Contact Resistance of cable samples (HFDA04-#2) extracted from cos-theta magnet HFDA04

G. Ambrosio, E. Barzi, L. Elementi, D. Turrioni

Abstract:

This note present the results of the measurement of the Inter-strand Contact Resistance of four cables extracted from magnet HFDA04 (Nb_3Sn Cos-theta dipole). Each cable sample was instrumented with 8 voltage taps in order to compute the adjacent (R_A) and cross-over (R_C) resistance from the voltage distribution across the cable.

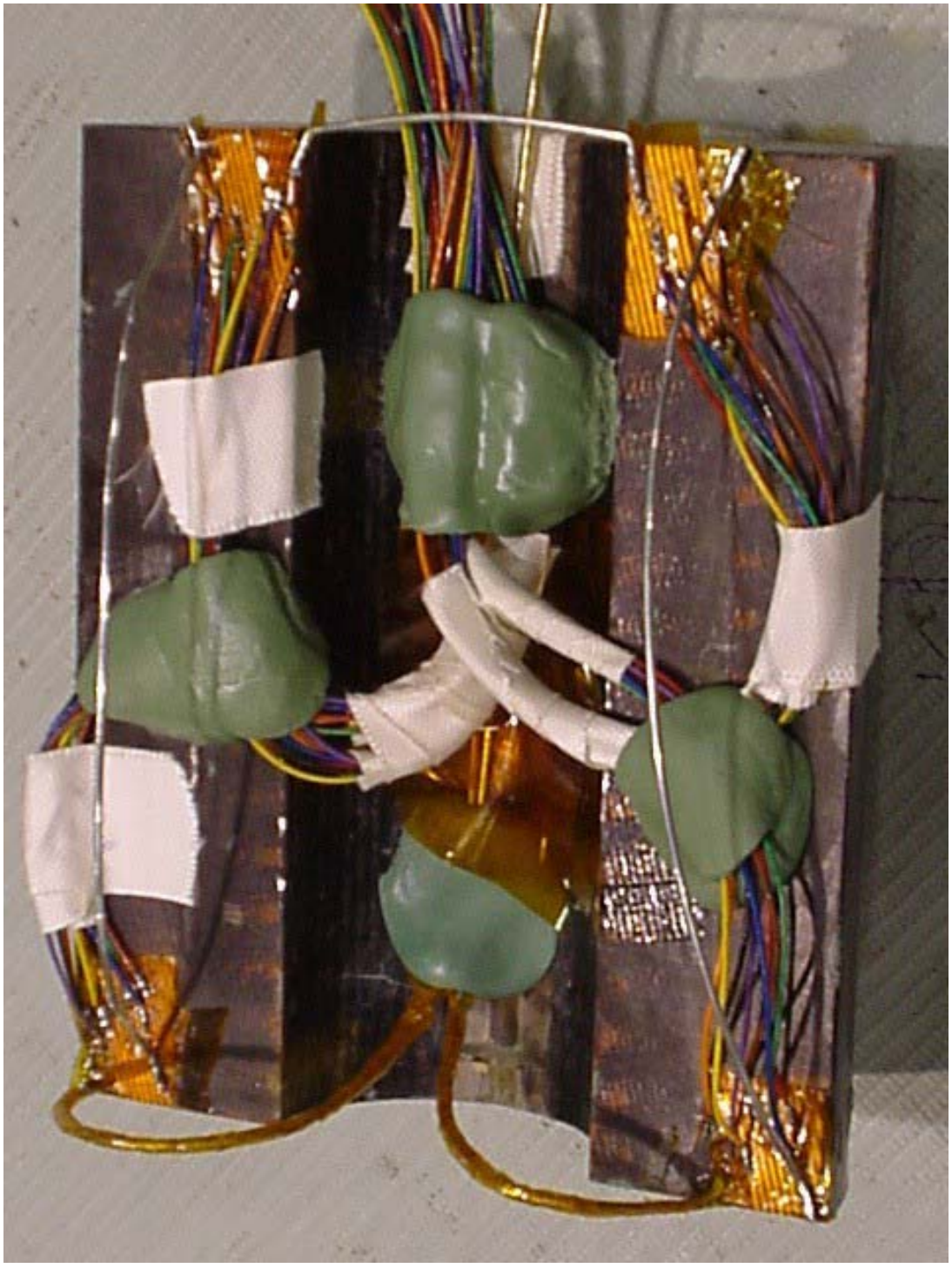


Fig. 1: The sample HFDA04-#2 instrumented and ready for test.

1. SAMPLE DESCRIPTION

The sample was a five-inch (127 mm) long section of the straight part of a coil of HFDA04. The cable parameters are presented in Table 1. All four cables on the mid-plane were instrumented and tested (Fig. 1). The technique used to instrument the cables is described in [1]. This sample was previously tested with two voltage taps on each cable. The results are presented in [1] and compared with the present results in Table 2. The original experimental set-up, using a larger cryostat with a load cell, was described in [1]. Since the nano-voltmeter scanner is limited to eight channels, a new cryostat was adapted for these measurements. Its top flange has five connectors each one used for a different sample (so that five samples can be tested during the same cooldown). The scanner can be used to read the signals of any sample by connecting it to the appropriate connector. This new system produced very clean data with a drift smaller than 1 μV, which was an order of magnitude smaller than in [1].

TABLE 1: Cable parameters

Cable	28-1-No
Strand diameter	1
Number of strands	28
Cable width (mm)	14.23
Cable thickness: thin-thick edge (mm)	1.69-1.91
Cable pitch length (mm)	110
Stainless steel core thickness (μm)	No core

2. RESULTS

The results are presented in Table 2. R_A is the adjacent resistance and R_C the crossover resistance. The total resistance (R_{TOT}) between the strands soldered to the current leads is compared with the values previously measured on the same sample. Sample C shows a large difference confirming the large error in the previous measurement of this sample mentioned in [1]. This error was due to a displacement, during soldering, of a voltage tap close to a lead (strand # 15). Because of the wrong position the voltage tap measured part of the voltage between the lead and the strand. Sample A had a similar problem during this test series. The V/I curve had a linear beginning followed by an

TABLE 2: Results and comparison with previous measurement of R_{TOT} of the same sample.

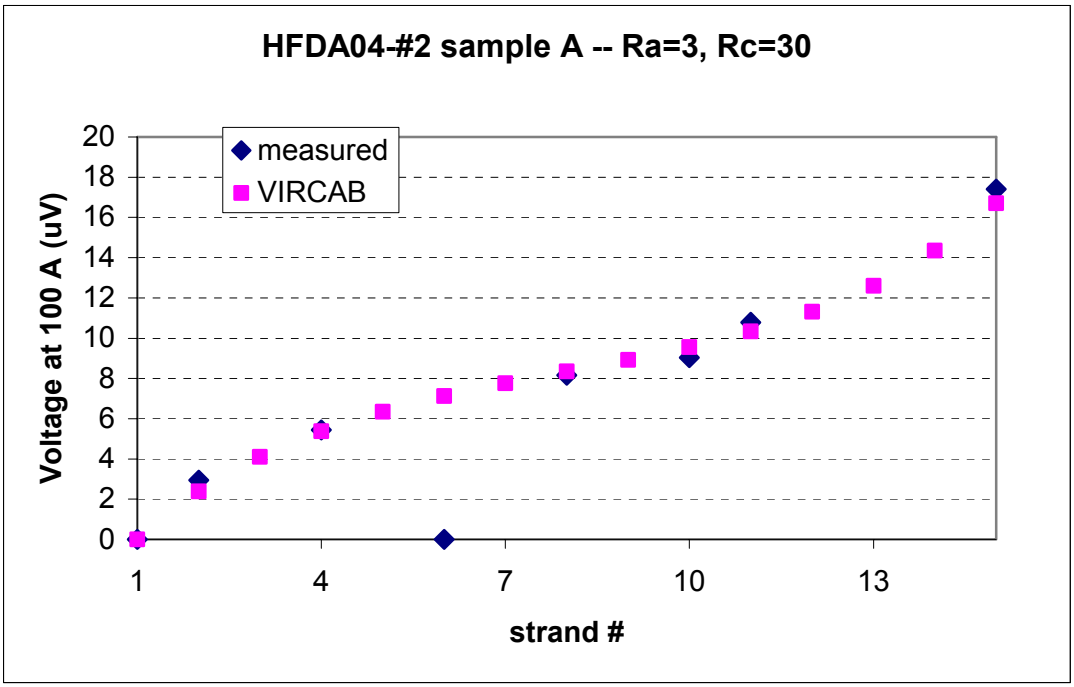
Sample	Coil layer	**R_A (μΩ)**	**R_C (μΩ)**	R_{TOT} (μΩ)	Old R_{TOT} (μΩ)	Comments
A	Outer	**3**	**30**	~ 0.2	0.31	
B	Inner	**~3**	**≥ 500**	~ 0.4	0.43	
C	Inner	**2.6-3**	**≥ 500**	0.33	26 ?	Old R_{TOT} had large error
D	Outer	**2.5**	**20**	~ 0.2		

exponential growth. Only the linear part was used in the analysis. The same voltage tap was missing on sample D and in Sample B was in contact with strand # 11. The soldering of this voltage tap is the most difficult part of the instrumentation and some more practice will be done before instrumenting another coil sample.
Figures 2 to 5 show the comparison between the measured voltage distribution (scaled to 100 A) in the samples and the voltages computed by VIRCAB assuming the values of Ra and Rc shown in the legend. The fits with VIRCAB were obtained by minimizing the error by hand. A Fortran routine is under development in order to make this process automatic and have a better evaluation of the error. The data analysis showed that this measurement technique cannot resolve values of Rc more than 200 times larger than Ra.

REFERENCES

1) G. Ambrosio, E. Barzi, L. Elementi, A.V. Zlobin, *"Measurement of inter-strand contact resistance in epoxy impregnated Nb_3Sn Rutherford cables",* to be published in the Proceedings of CEC/ICMC03

APPENDIX - PLOTS



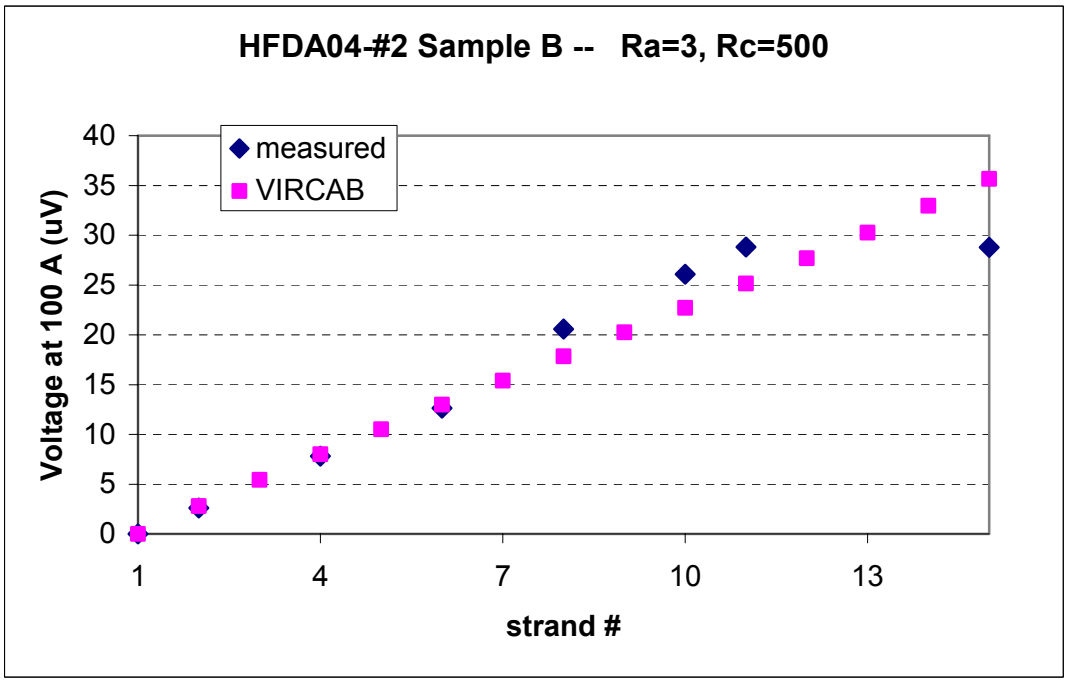
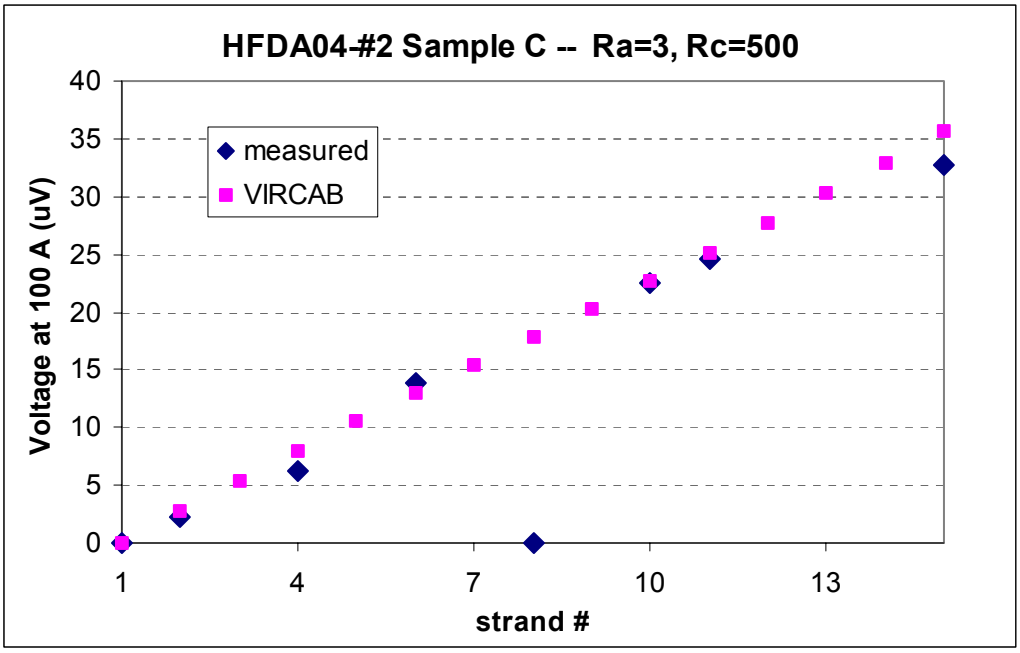


Fig. 2-3: Comparison between the measured voltage distribution (scaled to 100 A) and the voltages computed by VIRCAB assuming the values of Ra and Rc shown in the legend.



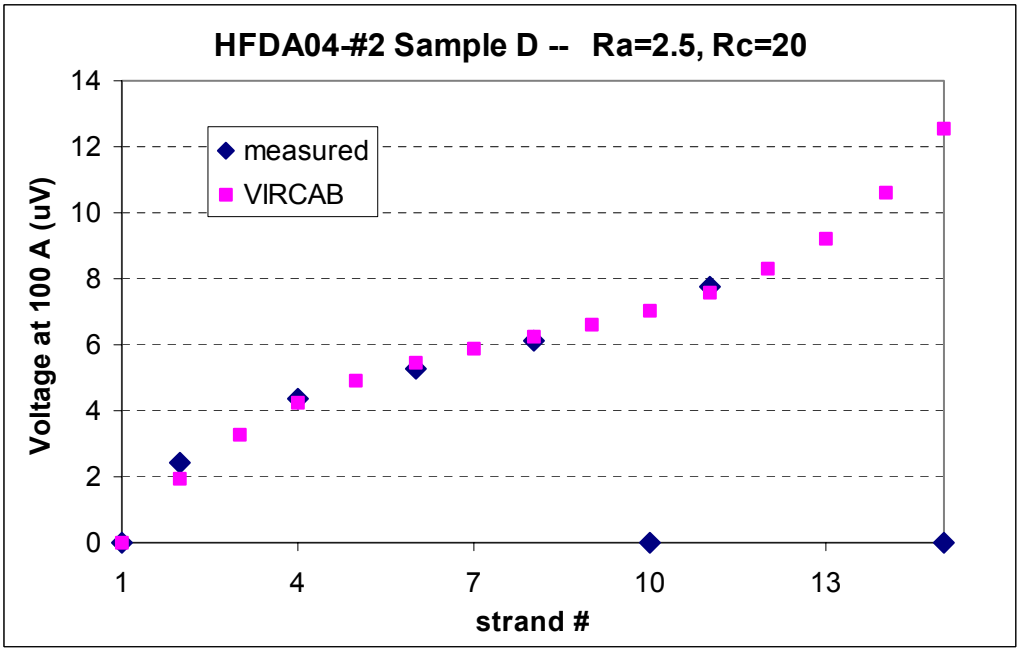


Fig. 4-5: Comparison between the measured voltage distribution (scaled to 100 A) and the voltages computed by VIRCAB assuming the values of Ra and Rc shown in the legend.